National Aeronautics and Space Administration

NASA’s Moon to Mars (M2M) Transit Habitat (TH) Refinement Point of Departure (PoD) Design

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Objective

What is the TH?

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GR&A/Functional Allocations

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CONOPS & Considerations

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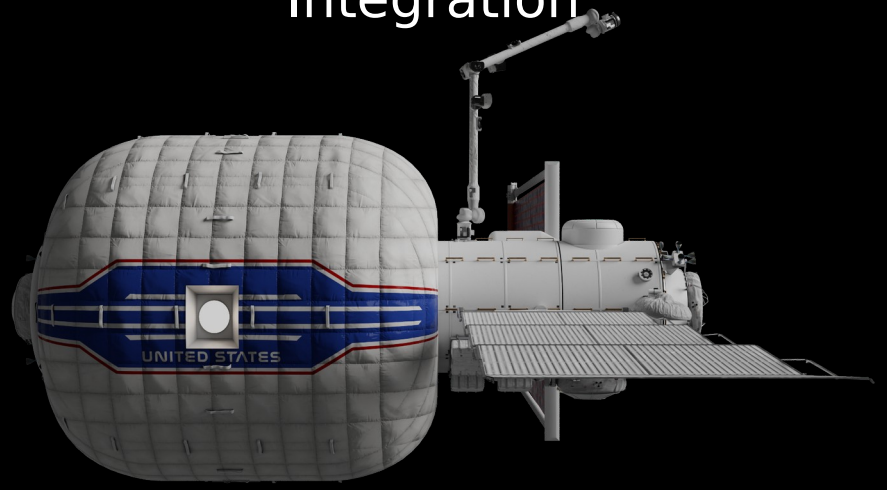
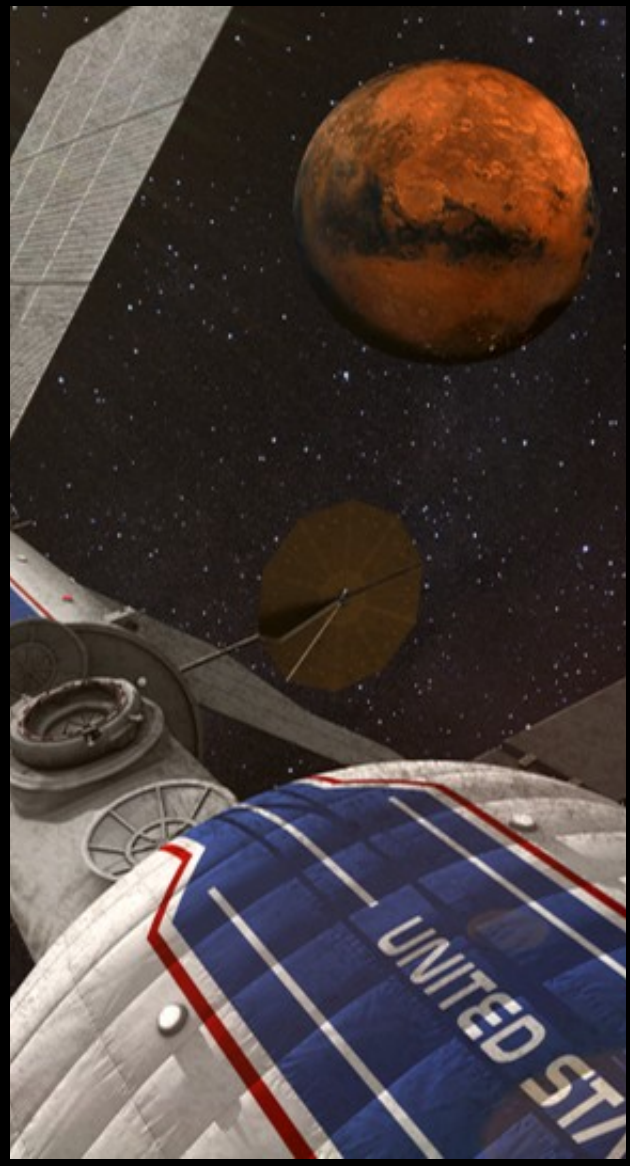
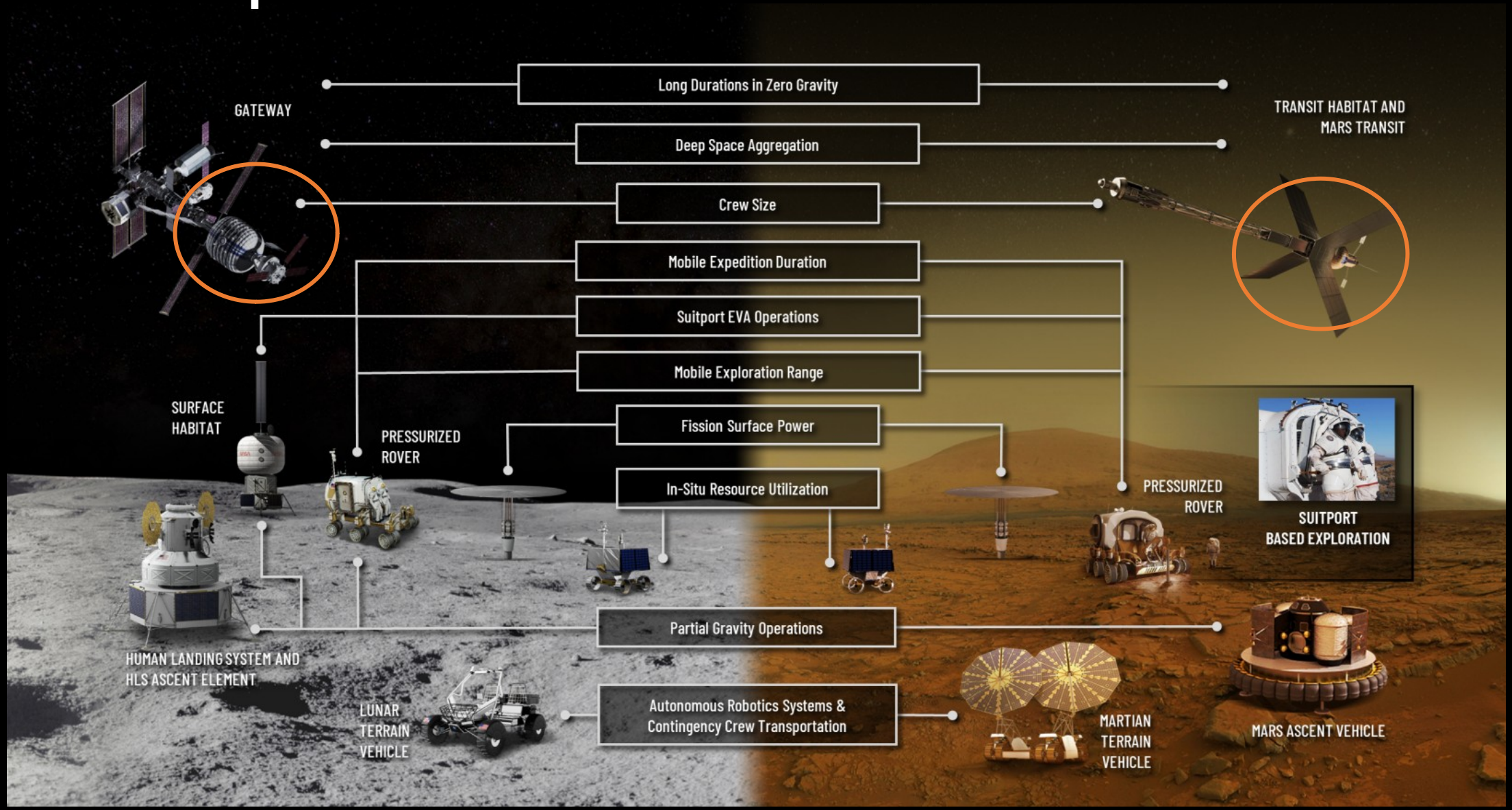
Moon to Mars (M2M) Integration

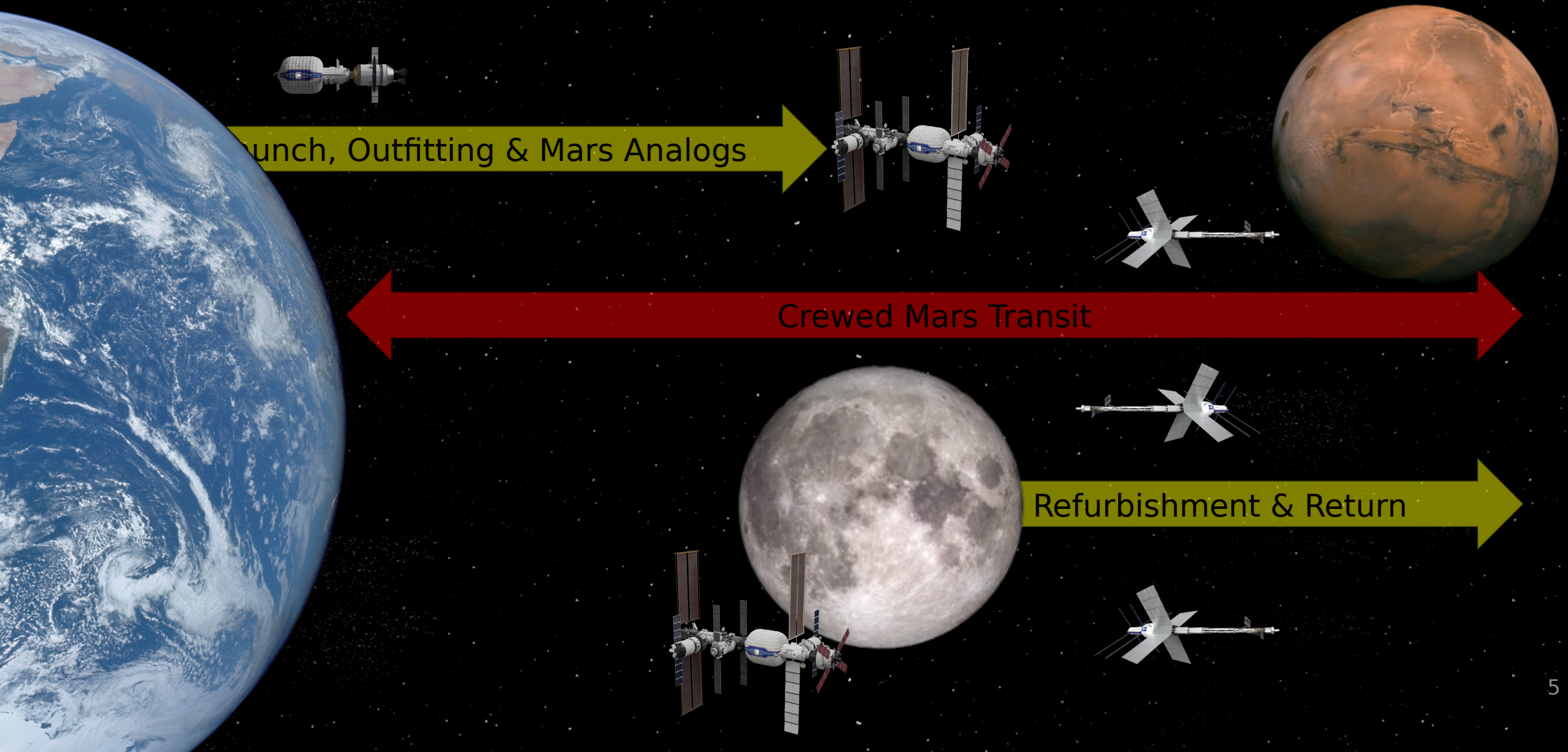


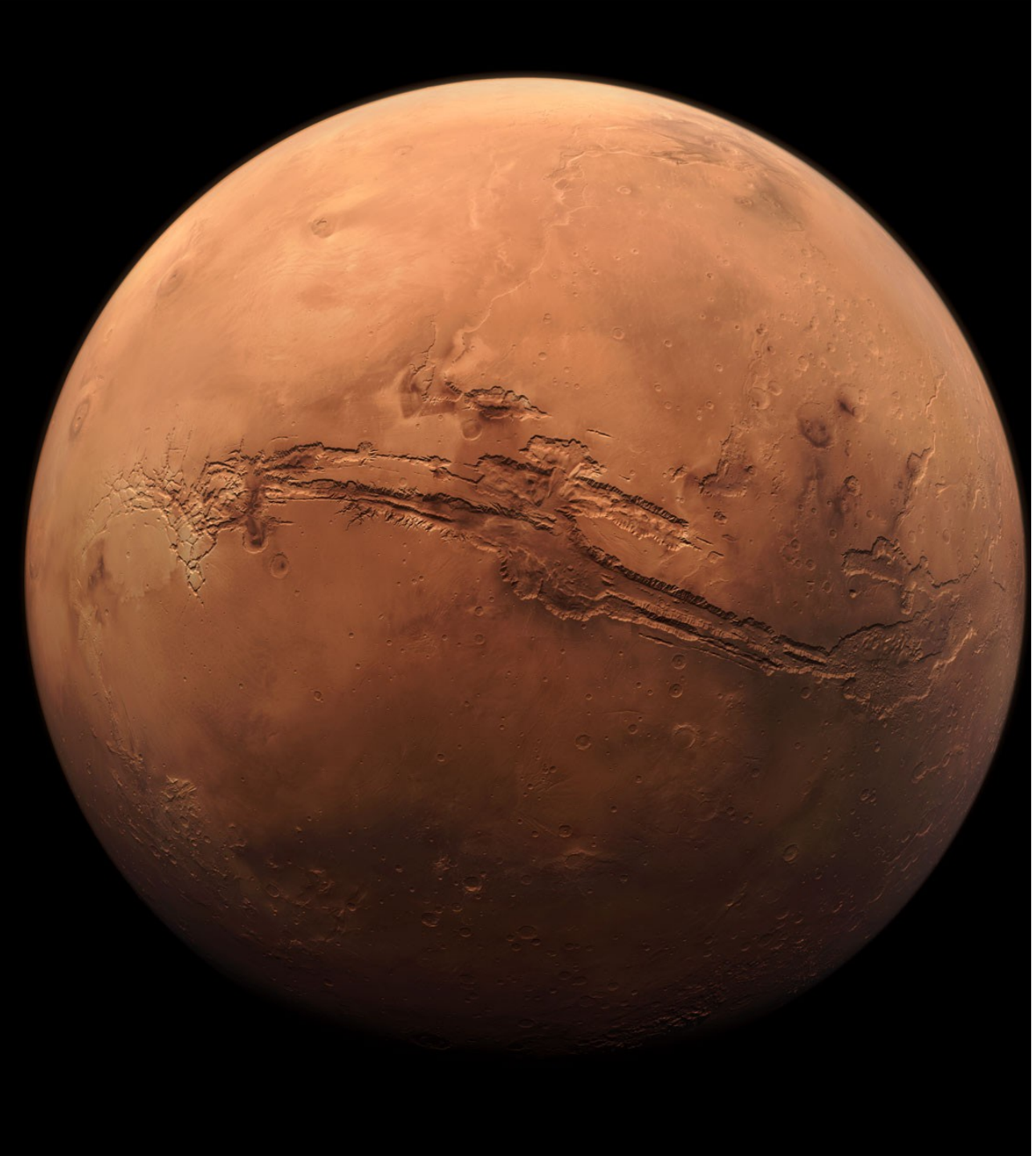


M2M Exploration Element Concepts



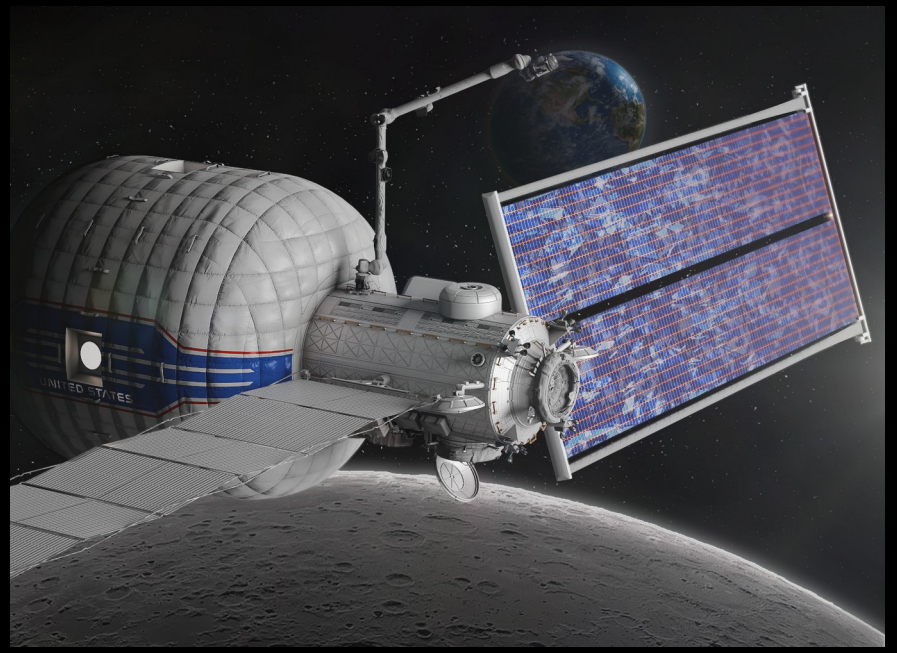
M2M Integration & CONOPS Phases

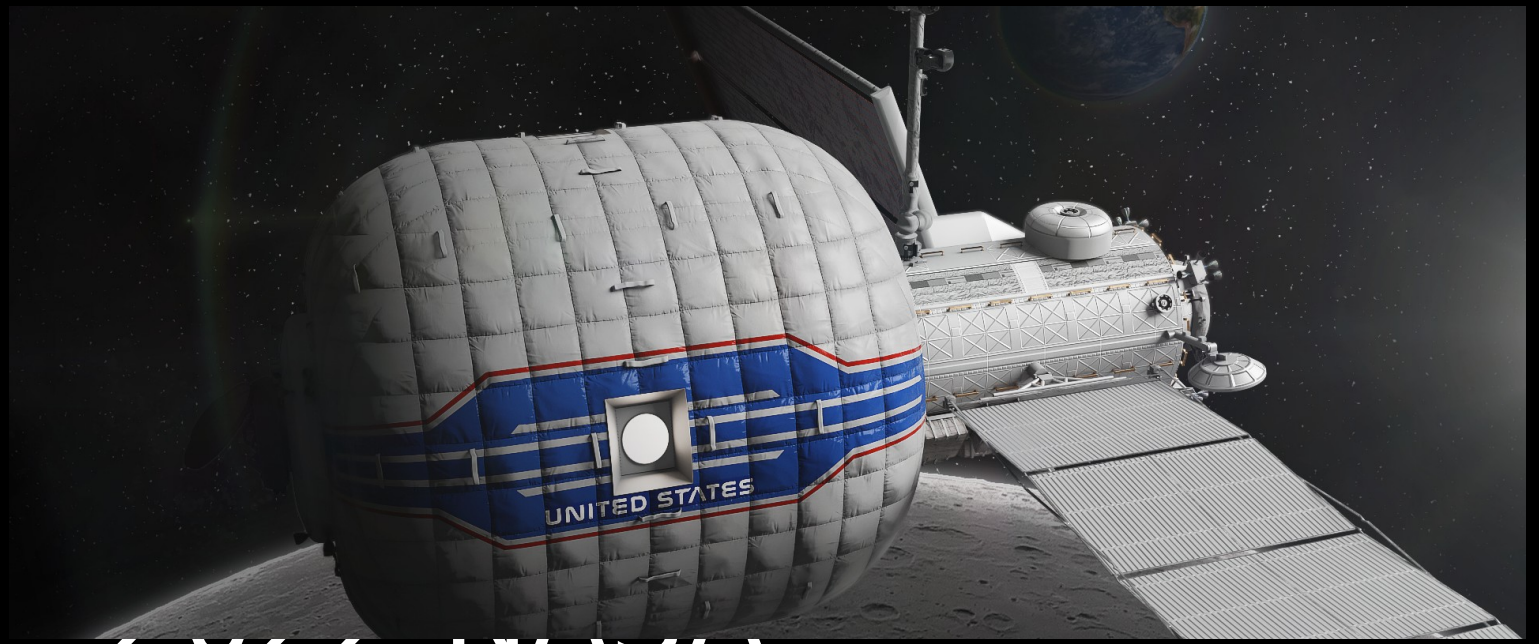


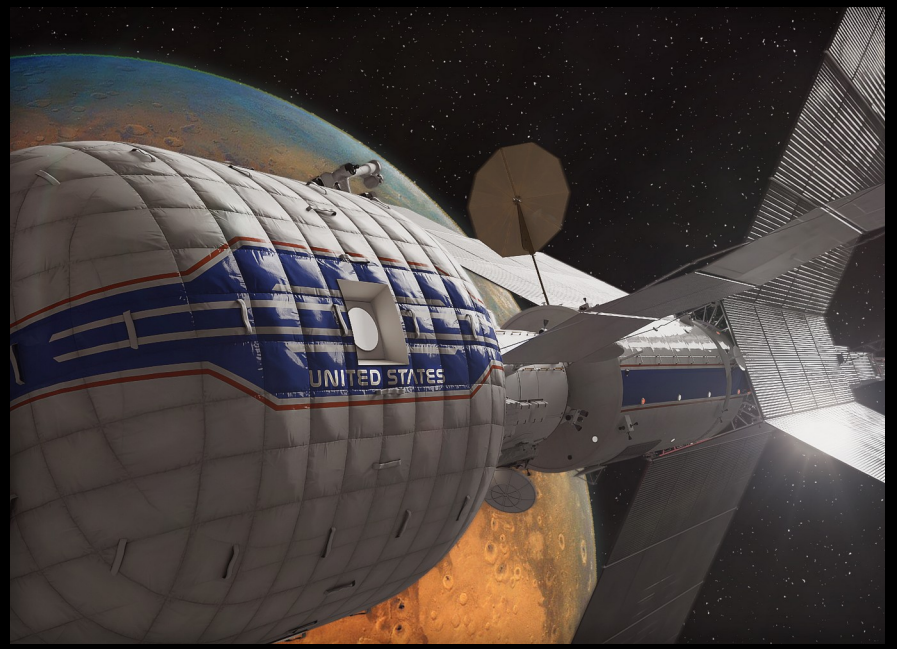


Key Mission & Functional Challenges

- No spares resupply chain during transit
- Impact on propulsion element size
- Waste and trash management in transit/loiter orbits
- Logistics storage capacity for mission
- Human health and performance for long duration missions
- Long duration shakedown
- Radiation & MMOD protection
- Communication delays/blackouts
- Ability to recover from major habitation failures



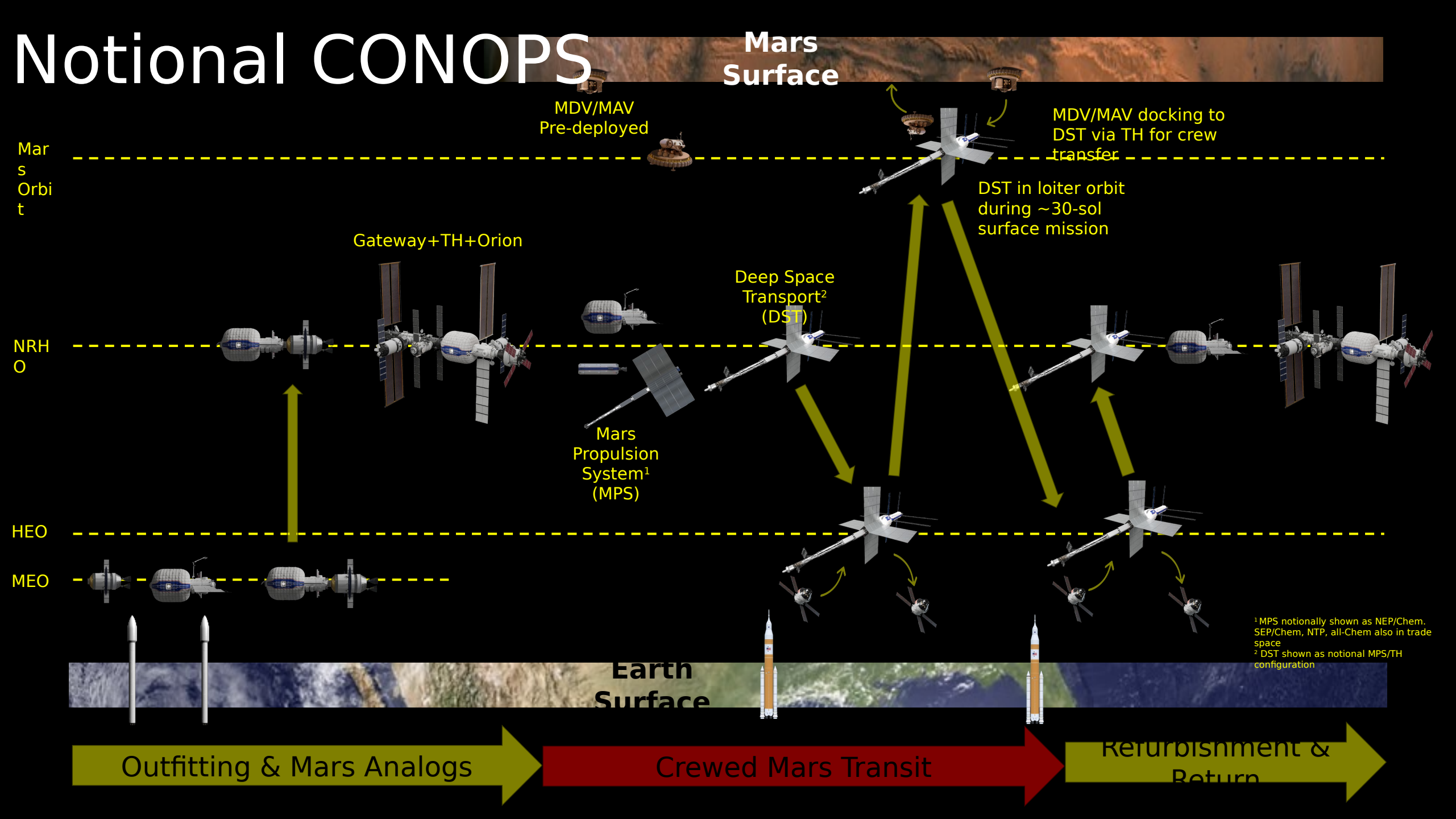




2022 NASA

Government Reference Transit Habitat Concept Overview

Notional CONOPS



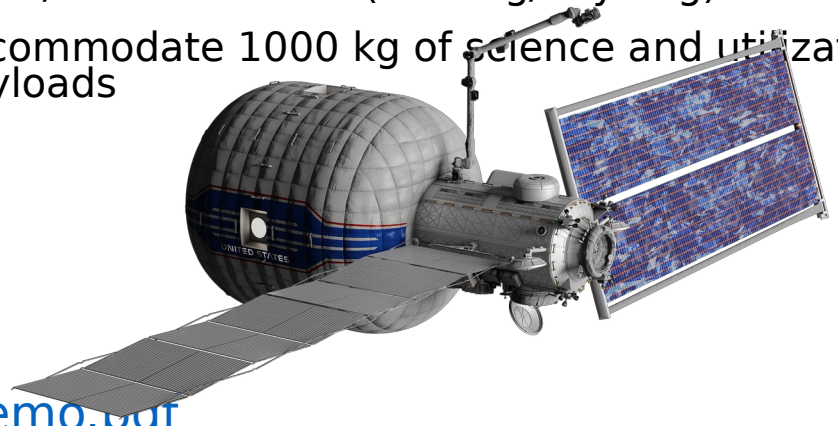
Ground Rules & Assumptions

Significant GRs:

- 4 crew for up to 1,200-day Mars Transit mission duration
- 26.4 mt target dry mass (including MGA and margin)
- Autonomous operation when uncrewed
- Max uncrewed dormancy of up to 3 years
- Minimum of 2 axial and 1 radial docking ports
- Performs a series of up to ~180d Mars Analog missions while docked at Gateway
- Self-sufficient habitat once fully deployed at orbits up to 1.0 AU, capable of receiving power from Mars propulsion system beyond 1.6 AU
- 14.7 psia 21% O2 atmosphere nominal, capable of 10.2 psia 26.5% O2 during Gateway docked open-hatch ops
- Safe Haven and Solar Proton Event (SPE) Shelter
- 15-year life with multiple missions of increasing duration
- TH Sparing and Maintenance - Manifested to achieve 99% system availability

Significant Assumptions:

- Near-Rectilinear Halo Orbit (NRHO) via Commercial Launch Vehicle(s)(CLV). Options for SLS cargo delivery are possible but should feed cost assessments.
- Early 2030's launch with Mars mission in late 2030's
- Replenishable Reaction Control System (RCS) through docking or Gateway interface between mission phases (analogs, Mars Propulsion System (MPS) shakedown, Mars transit)
- Contingency EVA airlock
- Trash/waste removal (11.6 kg/day avg)
- Accommodate 1000 kg of science and utilization payloads



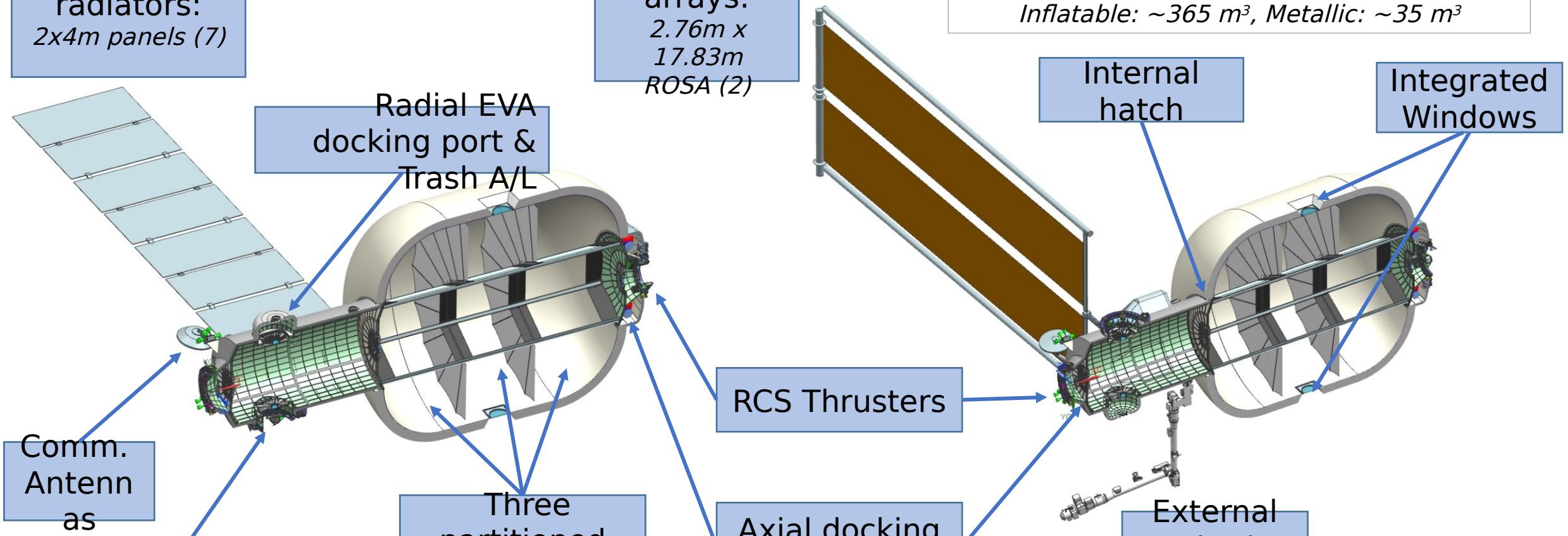
M2M Habitation Considerations Technical Memo.pdf

TH Concept OML Features

Deployable radiators:
2x4m panels (7)

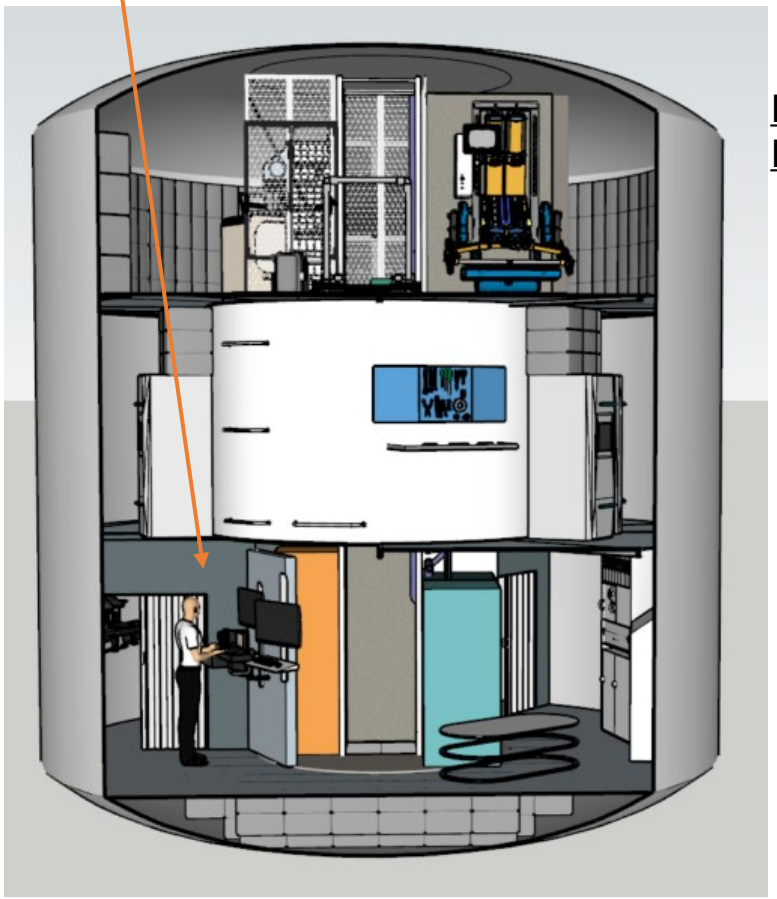
Deployable solar arrays:
2.76m x 17.83m ROSA (2)

TH Overall Pressurized Volume:
~400 m^3
Inflatable: ~365 m^3, Metallic: ~35 m^3



TH Concept Interior Features

Level 1 – Galley, Command & Control, Medical, Hand Washing Station, UWMS (1 of 2), Logistics Management, Trash Management



Floor Heights

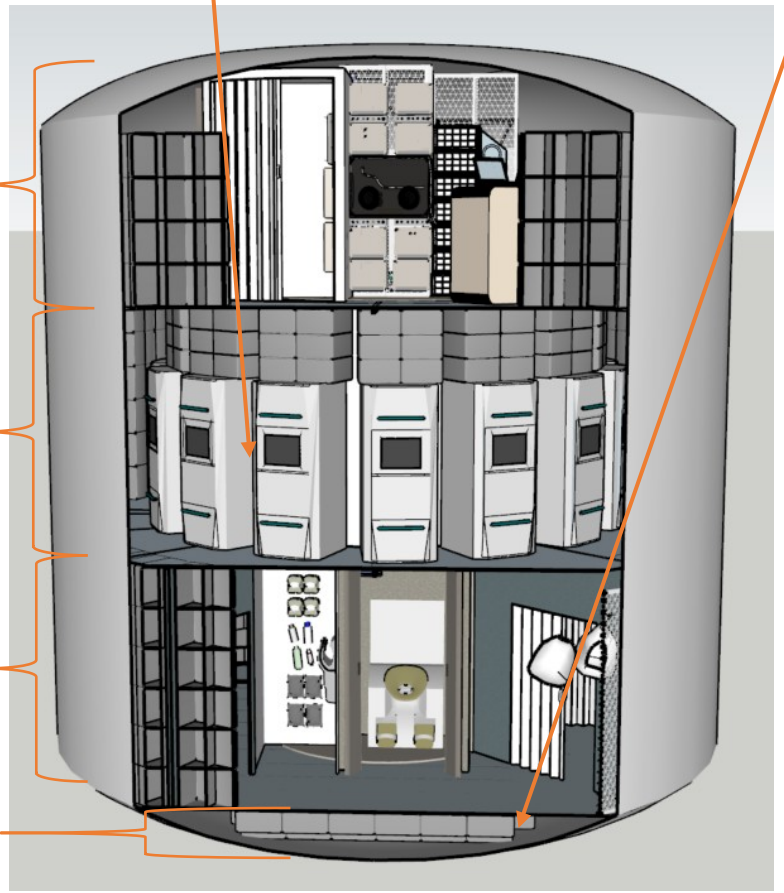
2.5m

2.65 m

2.55 m

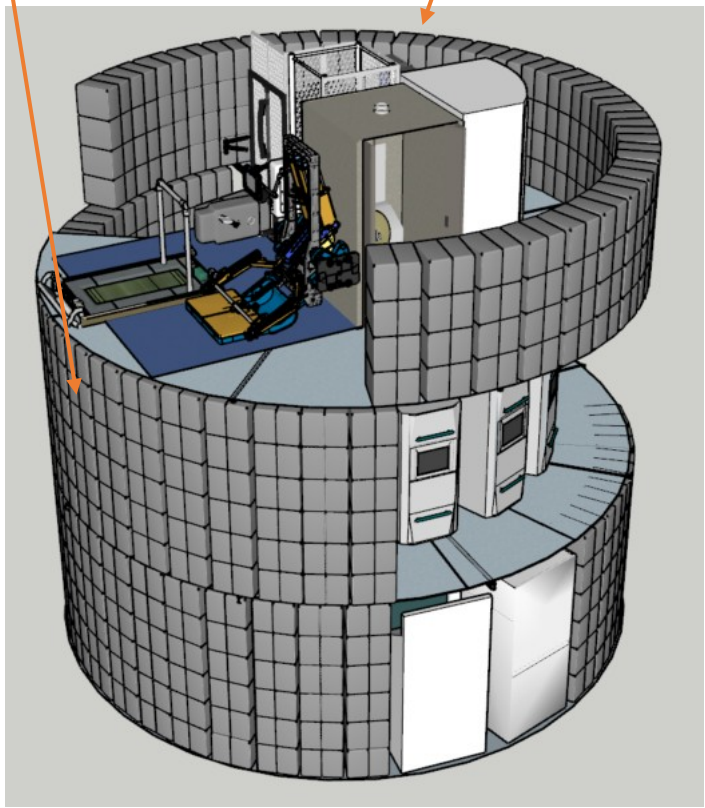
0.8 m

Level 2 – Crew Quarters, Sub-Systems, Maintenance Stations



Storage – CTBs lining the outer wall, additional storage below Level 1

Level 3 – Exercise, Utilization, UWMS (2 of 2), Hygiene Station



TH Concept: Mass Summary

SBS ID	Functional Category	Qty	Basic Mass kg	MGA / Reserves %	Predicted Mass kg
1.0	BODY STRUCTURES	6	4,057	20%	4,860
2.0	CONNECTION & SEPARATION SYSTEMS	3	1,163	4%	1,210
3.0	LAUNCH/TAKEOFF & LANDING SUPPORT SYSTEMS	1	260	25%	325
4.0	NATURAL & INDUCED ENVIRON PROTECT SYSTEMS	2	1,869	18%	2,206
5.0	PROPULSION SYSTEMS	0	0	0.00	0
6.0	POWER SYSTEMS	33	1,710	23%	2,100
7.0	COMMAND & DATA HANDLING (C&DH) SYSTEMS	51	829	11%	920
8.0	GUIDANCE, NAVIGATION & CONTROL (GN&C) SYSTEMS	1,013	691	14%	789
9.0	COMMUNICATIONS & TRACKING (C&T) SYSTEMS	143	492	7%	526
10.0	CREW DISPLAYS & CONTROLS	48	160	8%	173
11.0	THERMAL CONTROL SYSTEMS (TCS)	1,060	1,554	17%	1,821
12.0	ENVIRONMENTAL CONTROL SYSTEMS (ECS)	96	1,781	8%	1,919
13.0	CREW/HABITATION SUPPORT SYSTEMS	254	4,902	19%	5,831
14.0	EXTRAVEHICULAR ACTIVITY (EVA) SUPPORT SYSTEMS	78	824	13%	932
15.0	IN-SITU RESOURCE & CONSUMABLES PRODUCTION SYSTEMS	0	0	0.00	0
16.0	IN-SPACE MANUFACTURING & ASSEMBLY SYSTEMS	0	0	0.00	0
17.0	MANIPULATION & MAINTENANCE SYSTEMS	22	709	25%	889
18.0	PAYLOAD PROVISIONS	0	0	0.00	0
	MANUFACTURER'S EMPTY MASS	**2,810**	**21,002**	**16.65%**	**24,498.71**
	CREW ITEMS/CONSUMABLES & PORTABLE EQUIP	72	10,994	1%	11,100
	EQUIPMENT SPARES & MAINTENANCE ITEMS	3	7,397	0%	7,397
	ATMOSPHERE & SYSTEM CONSUMABLES/RESIDUALS	9	334	0%	334
	OPERATIONAL EMPTY MASS	***2,894***	***39,726***	***9%***	***43,330***
19.0	PAYLOADS & RESEARCH	5	1,328	0	1,328
	PROPULSION & REACTION CONTROL EXPENDABLES	0	1,562	0	1,562
	GROSS MASS	**2,899**	**42,616**	**8%**	**46,220**

Note: Mass margin & PMR approach defined in HEO-MD-1010, but not included within this publication.

Key mass drivers:

- Mission duration
- Spares philosophy
- Planned maintenance
- Crew size (currently 4)
- Technology selection (Power storage, Regen ECLSS, etc.)
- Reliability and maintainability criteria
- Risk posture
- MGA and margin requirements (only MGA shown)

Control mass target: 26,400 kg

Departure mass currently ~50 tons!

Future Work

Continued concept refinement alongside M2M architecture

- Further CONOPS definition within each operational phase
  - Phase 1: TH in cis-lunar NRHO with Gateway and MPS integration
  - Phase 2: Crewed Transit Time and Mars Surface Mission support
  - Phase 3: Refurbishment activities for subsequent crewed Mars missions
- Interior outfitting optimization activities
  - Stowed and frozen food management
  - Crew health and performance optimization (exercise/countermeasure systems)
- Mass refinement and logistics loading plans

Continued focus on technology development and maturation activities

- Deep dive provided in 2023 IEEE Paper “An Analysis of Exploration Capability Gaps for Future Habitation Systems to Inform Risk Assessment and Development Priorities” (T. Prater et al.)

Continued public/industry engagement and cross-agency integration

Authors & Contributors

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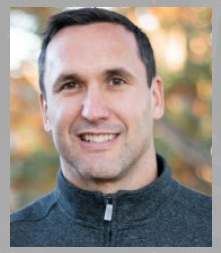

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